

What is claimed is:

1           1. A method for robustly producing a motion compensated interpolation video frame, the  
2 method comprising:  
3           constructing N motion compensated interpolated frames between two existing  
4           frames F1 and F2, wherein N comprises an integer with a value of at least  
5           2; and  
6           fusing the N motion compensated interpolated frames into a single motion  
7           compensated interpolated frame.

1           2. The method of claim 1 wherein constructing each of the N motion compensated  
2 interpolated frames between the two existing frames F1 and F2 further comprises:  
3           selecting a first set of pixels in F1, wherein the pixel sets selected for each of the  
4           N motion compensated frames varies;  
5           selecting a corresponding second set of pixels in F2, wherein the corresponding  
6           pixel sets selected for each of the N motion compensated frames varies;  
7           generating a first mesh for the first set of pixels and a second mesh for the second  
8           set of pixels;  
9           estimating a first flow of motion from the first set of pixels to the second set of  
10          pixels, and a second flow of motion from the second set of pixels to the  
11          first set of pixels;  
12          generating a first motion compensated mesh based on the first mesh and the first  
13          estimated flow of motion, and a second motion compensated mesh based  
14          on the second mesh and the second estimated flow of motion;

15           computing a first warped image by warping F1 using the first mesh and the first  
16           motion compensated mesh, and a second warped image by warping F2  
17           using the second mesh and the second motion compensated mesh; and  
18           linearly combining the first warped image and the second warped image.

1           3. The method of claim 2 wherein selecting a set of pixels in a frame further comprises:  
2           classifying some pixels in the frame as having high spatial frequency contents and  
3           selecting the classified pixels, wherein the specific classification criteria is  
4           different for each of the N motion compensated frames.

1           4. The method of claim 2 wherein generating a mesh for a set of pixels further  
2 comprises:  
3           fitting a polygonal mesh to the set of pixels.

1           5. The method of claim 4 wherein fitting a polygonal mesh to a set of pixels further  
2 comprises:  
3           applying a Delaunay triangulation to the set of pixels, using edges of the  
4           associated frame as imposed boundaries.

1           6. The method of claim 2 wherein estimating a flow of motion between two sets of pixels  
2 further comprises:  
3           applying an optical flow constraint equation to the first set of pixels, the optical  
4           flow constraint equation comprising  $x * u + y * v + t = 0$ , wherein u and v  
5           are unknown components of the flow and x, y and t stand for  
6           differentiation.

1           7. The method of claim 1 wherein fusing the N motion compensated interpolated frames  
2 into a single, motion compensated interpolated frame further comprises:

3                   for each pixel x, y in a final fused motion compensated interpolated frame:

4                           applying a scalar median filter componentwise to a corresponding pixel in

5                                   each of the N motion compensated interpolated frames 1-N to

6                                   produce a resulting pixel x', y'; and

7                           setting x, y to a corresponding pixel from a one of the N motion

8                                   compensated interpolated frames that is color nearest to x', y'.

1           8. A computer readable medium containing a computer program product for robustly  
2 producing a motion compensated interpolation video frame, the computer program product  
3 comprising:

4                   program code for constructing N motion compensated interpolated frames

5                           between two existing frames F1 and F2, wherein N comprises an integer

6                                   with a value of at least 2; and

7                           program code for fusing the N motion compensated interpolated frames into a

8                                   single motion compensated interpolated frame.

1           9. The computer readable medium of claim 8 wherein the program code for constructing  
2 each of the N motion compensated interpolated frames between the two existing frames F1 and  
3 F2 further comprises:

4                           program code for selecting a first set of pixels in F1, wherein the pixel sets

5                                   selected for each of the N motion compensated frames varies;

6           program code for selecting a corresponding second set of pixels in F2, wherein  
7           the corresponding pixel sets selected for each of the N motion  
8           compensated frames varies;  
9           program code for generating a first mesh for the first set of pixels and a second  
10          mesh for the second set of pixels;  
11          program code for estimating a first flow of motion from the first set of pixels to  
12          the second set of pixels, and a second flow of motion from the second set  
13          of pixels to the first set of pixels;  
14          program code for generating a first motion compensated mesh based on the first  
15          mesh and the first estimated flow of motion, and a second motion  
16          compensated mesh based on the second mesh and the second estimated  
17          flow of motion;  
18          program code for computing a first warped image by warping F1 using the first  
19          mesh and the first motion compensated mesh, and a second warped image  
20          by warping F2 using the second mesh and the second motion compensated  
21          mesh; and  
22          program code for linearly combining the first warped image and the second warped  
23          image.

1           10. The computer readable medium of claim 9 wherein the program code for selecting a  
2           set of pixels in a frame further comprises:

3           program code for classifying some pixels in the frame as having high spatial  
4           frequency contents and selecting the classified pixels, wherein the specific

5 classification criteria is different for each of the N motion compensated  
6 frames.

1 11. The computer readable medium of claim 9 wherein the program code for generating  
2 a mesh for a set of pixels further comprises:  
3 program code for fitting a polygonal mesh to the set of pixels.

1 12. The computer readable medium of claim 11 wherein the program code for fitting a  
2 polygonal mesh to a set of pixels further comprises:  
3 program code for applying a Delaunay triangulation to the set of pixels, using  
4 edges of the associated frame as imposed boundaries.

1 13. The computer readable medium of claim 9 wherein the program code for estimating  
2 a flow of motion between two sets of pixels further comprises:  
3 program code for applying an optical flow constraint equation to the first set of  
4 pixels, the optical flow constraint equation comprising  $x * u + y * v + t =$   
5 0, wherein u and v are unknown components of the flow and x, y and t  
6 stand for differentiation.

1 14. The computer readable medium of claim 8 wherein the program code for fusing the  
2 N motion compensated interpolated frames into a single, motion compensated interpolated frame  
3 further comprises:  
4 program code for, for each pixel x, y in a final fused motion compensated  
5 interpolated frame:

6                   applying a scalar median filter componentwise to a corresponding pixel in  
7                   each of the N motion compensated interpolated frames 1-N to  
8                   produce a resulting pixel  $x'$ ,  $y'$ ; and  
9                   setting  $x$ ,  $y$  to a corresponding pixel from a one of the N motion  
10                  compensated interpolated frames that is color nearest to  $x'$ ,  $y'$ .

1           15. A computer system for robustly producing a motion compensated interpolation video  
2 frame, the computer system comprising:

3                   means for constructing N motion compensated interpolated frames between two  
4                   existing frames F1 and F2, wherein N comprises an integer with a value of  
5                   at least 2; and  
6                   means for fusing the N motion compensated interpolated frames into a single  
7                   motion compensated interpolated frame.

1           16. The computer system of claim 15 wherein the means for constructing each of the N  
2 motion compensated interpolated frames between the two existing frames F1 and F2 further  
3 comprises:

4                   means for selecting a first set of pixels in F1, wherein the pixel sets selected for  
5                   each of the N motion compensated frames varies;  
6                   means for selecting a corresponding second set of pixels in F2, wherein the  
7                   corresponding pixel sets selected for each of the N motion compensated  
8                   frames varies;  
9                   means for generating a first mesh for the first set of pixels and a second mesh for  
10                  the second set of pixels;

11 means for estimating a first flow of motion from the first set of pixels to the  
12 second set of pixels, and a second flow of motion from the second set of  
13 pixels to the first set of pixels;  
14 means for generating a first motion compensated mesh based on the first mesh  
15 and the first estimated flow of motion, and a second motion compensated  
16 mesh based on the second mesh and the second estimated flow of motion;  
17 means for computing a first warped image by warping F1 using the first mesh and  
18 the first motion compensated mesh, and a second warped image by  
19 warping F2 using the second mesh and the second motion compensated  
20 mesh; and  
21 means for linearly combining the first warped image and the second warped image.

1 17. The computer system of claim 16 wherein the means for selecting a set of pixels in a  
2 frame further comprises:

3 means for classifying some pixels in the frame as having high spatial frequency  
4 contents and selecting the classified pixels, wherein the specific  
5 classification criteria is different for each of the N motion compensated  
6 frames.

1 18. The computer system of claim 16 wherein the means for generating a mesh for a set  
2 of pixels further comprises:

3 means for fitting a polygonal mesh to the set of pixels.

1 19. The computer system of claim 18 wherein the means for fitting a polygonal mesh to  
2 a set of pixels further comprises:

3 means for applying a Delaunay triangulation to the set of pixels, using edges of  
4 the associated frame as imposed boundaries.

1 20. The computer system of claim 16 wherein the means for estimating a flow of motion  
2 between two sets of pixels further comprises:

3 means for applying an optical flow constraint equation to the first set of pixels,  
4 the optical flow constraint equation comprising  $x * u + y * v + t = 0$ ,  
5 wherein u and v are unknown components of the flow and x, y and t stand  
6 for differentiation.

1 21. The computer system of claim 15 wherein the means for fusing the N motion  
2 compensated interpolated frames into a single, motion compensated interpolated frame further  
3 comprises:

4 means for, for each pixel x, y in a final fused motion compensated interpolated  
5 frame:

6 applying a scalar median filter componentwise to a corresponding pixel in  
7 each of the N motion compensated interpolated frames 1-N to  
8 produce a resulting pixel x', y'; and

9 setting x, y to a corresponding pixel from a one of the N motion

10 compensated interpolated frames that is color nearest to x', y'.

1 22. A computer system for robustly producing a motion compensated interpolation video  
2 frame, the computer system comprising:



3 a software portion configured to construct N motion compensated interpolated  
4 frames between two existing frames F1 and F2, wherein N comprises an  
5 integer with a value of at least 2; and  
6 a software portion configured to fuse the N motion compensated interpolated  
7 frames into a single motion compensated interpolated frame.

1 23. The computer system of claim 22 wherein the software portion configured to  
2 construct each of the N motion compensated interpolated frames between the two existing  
3 frames F1 and F2 further comprises:

4 a software portion configured to select a first set of pixels in F1, wherein the pixel  
5 sets selected for each of the N motion compensated frames varies;  
6 a software portion configured to select a corresponding second set of pixels in F2,  
7 wherein the corresponding pixel sets selected for each of the N motion  
8 compensated frames varies;  
9 a software portion configured to generate a first mesh for the first set of pixels and  
10 a second mesh for the second set of pixels;  
11 a software portion configured to estimate a first flow of motion from the first set  
12 of pixels to the second set of pixels, and a second flow of motion from the  
13 second set of pixels to the first set of pixels;  
14 a software portion configured to generate a first motion compensated mesh based  
15 on the first mesh and the first estimated flow of motion, and a second  
16 motion compensated mesh based on the second mesh and the second  
17 estimated flow of motion;

18 a software portion configured to compute a first warped image by warping F1  
19 using the first mesh and the first motion compensated mesh, and a second  
20 warped image by warping F2 using the second mesh and the second  
21 motion compensated mesh; and  
22 a software portion configured to linearly combine the first warped image and the  
23 second warped image.

1 24. The computer system of claim 23 wherein the software portion configured to select a  
2 set of pixels in a frame further comprises:

3 a software portion configured to classify some pixels in the frame as having high  
4 spatial frequency contents and selecting the classified pixels, wherein the  
5 specific classification criteria is different for each of the N motion  
6 compensated frames.

1 25. The computer system of claim 23 wherein the software portion configured to  
2 generate a mesh for a set of pixels further comprises:

3 a software portion configured to fit a polygonal mesh to the set of pixels.

1 26. The computer system of claim 25 wherein the software portion configured to fit a  
2 polygonal mesh to a set of pixels further comprises:

3 a software portion configured to apply a Delaunay triangulation to the set of  
4 pixels, using edges of the associated frame as imposed boundaries.

1 27. The computer system of claim 23 wherein the software portion configured to  
2 estimate a flow of motion between two sets of pixels further comprises:

3 a software portion configured to apply an optical flow constraint equation to the  
4 first set of pixels, the optical flow constraint equation comprising  $x * u + y$   
5  $* v + t = 0$ , wherein  $u$  and  $v$  are unknown components of the flow and  $x$ ,  $y$   
6 and  $t$  stand for differentiation.

1 28. The computer system of claim 22 wherein the software portion configured to fuse the  
2  $N$  motion compensated interpolated frames into a single, motion compensated interpolated frame  
3 further comprises:

4 a software portion configured to, for each pixel  $x$ ,  $y$  in a final fused motion  
5 compensated interpolated frame:

6 apply a scalar median filter componentwise to a corresponding pixel in

7 each of the  $N$  motion compensated interpolated frames 1- $N$  to

8 produce a resulting pixel  $x'$ ,  $y'$ ; and

9 set  $x$ ,  $y$  to a corresponding pixel from a one of the  $N$  motion compensated

10 interpolated frames that is color nearest to  $x'$ ,  $y'$ .